[0084] A micro-particle **416** can be positioned initially at a launch point within the interior channel **412**, just downstream of the flow-conditioning segment **414**, as shown. The micro-particle can have an outer cross-sectional shape in a plane perpendicular to an axis of the acceleration barrel **410** that is substantially similar in form, and only very slightly smaller in size, to the outer cross-sectional shape of the interior channel **412**.

[0085] Operation of the device **400** for needle-free blood draw is largely same as that described above for the device **300**, and is not described further.

[0086] Note that, as with the illustration of the device **200** in FIG. **2**, the neither the sizes of the components, nor their relatives sizes, of the devices **300** and **400** in FIGS. **3** and **4** are necessarily shown to scale.

3. ILLUSTRATIVE MICRO-PARTICLES

[0087] In accordance with example embodiments, the micro-particle can have a spherical, ellipsoidal, or cylindrical shape, and a characteristic size (e.g., diameter) in range of 10 μm (microns) −250 μm. The micro-particle can be metallic (e.g., iron) or biodegradable (e.g., salt, sugar, or polylactic-co-glycolic acid (PLGA)). The micro-particle can also be composed of multiple, smaller particles, or an agglomerate of smaller particles. For example, the micro-particle could be made of nano-sized gold particles bound together with biodegradable glue. In general, the higher the density of the micro-particle, the deeper the penetration of the dermal tissue. Other forms and compositions of micro-particles are possible as well. For example, the micro-particle could be a small droplet liquid, such as water. Further, the micro-particle could be positioned at the launch point with a small amount of liquid (e.g., water) just behind it (i.e., on the proximal—up stream—side of the particle). This configuration could be used to effectively increase the mass of the micro-particle, thereby boosting the total acquired momentum and resulting dermal penetration depth.

[0088] In further accordance with example embodiments, the micro-particle can provide therapeutic value beyond just inducing a micro-emergence of blood for a needle-free blood draw. For example, a micro-particle could carry medication for delivery into a patient. Additionally or alternatively, a micro-particle could have physical properties that make it suitable for diagnostic monitoring of a patient.

4. EXAMPLE METHOD

[0089] FIG. **5** is a flowchart illustrating an example method of needle-free blood draw using a hand-portable hyperspeed particle accelerator, according to an example embodiment. The example method could be carried out using a hand-portable hyperspeed particle accelerator such as the device **300** or **400** discussed above.

[0090] At step **502**, a negative-pressure barrel of a hand-portable hyperspeed particle accelerator is evacuated.

[0091] At step **504**, a trigger valve situated between a chamber volume and an open proximal end of an acceleration barrel is armed, or closed. Arming or closing the trigger valve creates a hydrostatic boundary between the chamber volume and the interior channel of the accelerator barrel.

[0092] At step **506**, a micro-particle is configured a launch point within the accelerator barrel, proximate to the trigger valve. As described above, the launch point is downstream of the trigger valve, but near the proximal end of the accelerator barrel.

[0093] At step **508**, the armed trigger valve is abruptly open to abruptly release pressurized gas from the chamber volume into the open proximal end of the accelerator barrel. As described above, the resulting surge of gas can accelerate the micro-particle to hyperspeed, approaching or exceeding the speed of sound. The micro-particle can thereby attain enough kinetic energy to pierce through a membrane, such as a thin foil, covering an aperture at the distal end of the negative-pressure barrel, and penetrate dermal tissue proximate to the aperture. Penetration of the dermal tissue can then result in a micro-emergence of blood at the surface of the dermal tissue.

[0094] At step **510**, at least a portion of blood from the micro-emergence of blood is drawn into the negative-pressure barrel through the aperture.

[0095] In further accordance with example embodiments, the hand-portable hyperspeed particle accelerator can be configured for multiple applications by repeating the steps **502**-**510**. Specifically, the negative-pressure barrel can be re-evacuated, the trigger valve can be re-armed, and a replacement micro-particle can be re-configured at the launch point. A subsequent application of needle-free blood drawing can then be accomplished by re-releasing the re-armed trigger valve, and again drawing at least a portion of blood from a subsequent micro-emergence of blood at the dermal tissue surface.

[0096] It will be appreciated that the steps shown in FIG. **5** are meant to illustrate a method in accordance with example embodiments. As such, various steps could be altered or modified, the ordering of certain steps could be changed, and additional steps could be added, while still achieving the overall desired operation.

[0097] The method illustrated in FIG. **5** can be viewed more generally as a method for creating a pore-size skin puncture by accelerating a micro-particle at a dermal tissue surface using a hand-portable hyperspeed micro-particle accelerator. The generalized steps of the method include configuring a micro-particle at a launch point at a proximal end of an accelerator barrel of a hand-portable hyperspeed micro-particle accelerator device. The accelerator barrel can be positioned lengthwise within an outer barrel of the hand-portable hyperspeed micro-particle accelerator device and can have an open distal end proximate to, and aligned with, an aperture at a distal end of the outer barrel. The hand-portable hyperspeed micro-particle accelerator device can be armed, such that it is placed in a ready state for accelerating the micro-particle. In the armed state, the hand-portable hyperspeed micro-particle accelerator device can then be triggered, thereby causing the micro-particle to accelerate from the launch point to the open distal end of the accelerator barrel and through the aperture with sufficient momentum to pierce dermal tissue and creating a surface puncture no larger than a dermal pore in size.

[0098] While the hand-portable hyperspeed micro-particle accelerator device has been described by way of example embodiment as a pneumatic accelerator, other embodiments of micro-particle accelerator mechanism are possible. For example, hyperspeed acceleration of a micro-particle could be achieve with an electromagnetic railgun, for example. Such an alternative embodiment could also be used for needle-free blood draw (or sub-dermal delivery of medicine or therapeutic monitoring substances) in manner similar to the methods discussed above.